The Evergreen Forests of the Pacific Northwest

HERE NATURE SEEMS TO HAVE PUT FORTH HER BEST EFFORTS. THE HIGH, SURROUNDING MOUNTAINS, THE SUMMITS OF WHICH ARE STUDDED WITH SNOW, THE BEAUTIFUL GROVES OF TIMBER THAT STUD THE SLOPES, THE RICH SWARDS OF GRASS THAT CARPET THE VALLEY, THE BEAUTIFUL STREAMS THAT COURSE THE VALLEY. . . ALL COMBINED TO MAKE THIS ONE OF THE MOST LOVELY SPOTS ON EARTH. IT ENTIRELY BAFFLES DESCRIPTION. HERE WE LAY THE BALANCE OF THE DAY, CONTEMPLATING THE GRANDEUR.

P.V. CRAWFORD
JULY 13, 1851

Green Mansions

SCOTT HOPKINS

BY FRANCES PHILIPEK, SHELLEY SMITH, AND RICHARD BROOK

The wonder and the fragility of the world's tropical rain forests are widely known; nearly every American schoolchild can describe rain forest plants and animals and the threats to their habitat. What is not so well known is that the continental United States and Canada have a rain forest too. From Alaska to California, the Northwest Coast is banded by one of the world's largest contiguous temperate evergreen forests including the rain forest on the Olympic Peninsula. The region also hosts a redwood forest and other unique forest ecosystems.

This is a land of paradox. Under the quiet, cool forest shade and damp carpets of moss lies an area red-hot and roiling with geological activity. The tallest living organisms on the planet, the giant redwood trees, are found in this temperate forest. The ecosystem that supports them is fueled in many respects by miniature lifeforms—fungi, lichens, and insects. The area's majestic forests and grand rivers have been the scene of some of the most contentious environmental issues of our time, including logging of old-growth forest and restoration of wild salmon populations.

In this article we will explore America's Pacific Northwest Coastal forest ecosystems, including the geology, plants, and animals that characterize this land of hidden contrasts. We will also discuss the area's human history and current land-management issues. Several activities included in the article illustrate important aspects of this ecosystem, and the accompanying foldout offers expanded activities and materials for classroom use.

Under the Green

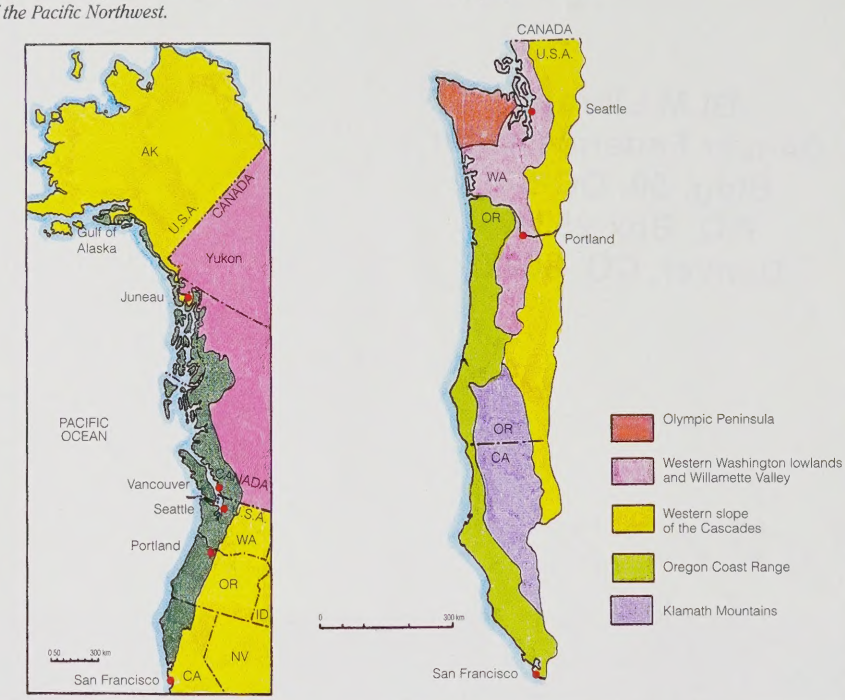
The Northwest temperate evergreen forest extends from southern Alaska to northern California and is nestled between the Pacific Ocean and the rugged peaks of the Cascade Mountains. Hundreds of coastal islands and Washington's vast Olympic Peninsula are also part of this ecosystem.

The eastern border of mountains was

The Pacific Northwest

Temporate evergreen forest ecosystem of the Pacific Northwest.

Physiographic provinces.



SHELLY FISCHMAN

formed 12–26 million years ago when one plate of the Earth's crust slid under another. This massive movement heated the Earth's interior rock to the point that it melted and formed magma. Under immense pressure, this molten rock was forced to the Earth's surface through weak spots in the Earth's crust and erupted as volcanoes; today, this rock forms the snow-capped peaks of the Cascades. The Coast Mountain Range and the Olympic Mountains on the western edge of this region resulted from the same geologic pressures that formed the Cascades, but here the forces wedged and folded formations first laid down as ancient sea floor.

Fiery volcanic forces rapidly built the Cascades, and glaciers slowly continue to wear them down. Moist Pacific air assures that the mountains are well watered and that more than 700 glaciers in the Cascade Range actively shape the landscape. Ice sheets of the last glacial age some 13,000 years ago shaped the Olympic Peninsula and the coastal areas and also carved out Puget Sound. Glacial activity and the runoff of glacial meltwater influence the location and flow of the numerous streams and rivers that traverse the Pacific Northwest.

Even though the Cascades are sheathed in ice today, residents of Portland and Seattle sometimes witness ashy, steaming proof that these mountains are still volcanically active. This area is the youngest and most geologically active part of the continent, and the mountains are still rising and shifting. Mount St. Helens, which erupted in May 1980, is a dramatic reminder of the underground powder keg. The spewing ash and gases leveled 60 km^2 of countryside, burying it with rivers of hot mud. This area marks a 1,100 km segment of the eastern edge of the Pacific Rim's "Ring of Fire." The Ring touches East Asia as well as North and South America. The explosive magma underlying this ring is constantly being replenished as oceanic plates dive and melt beneath the coasts.

But in the peaceful forest one would not guess there is such chaos below. The temperate evergreen forest of the Northwest Coast is situated mostly in coastal areas and has mountains less than 3,000 m high. Precipitation is abundant, with 65–400 cm of rain and snow a year.

Captions for first page of article, from left to right:

1. *The endangered Northern spotted owl has been at the center of Northwest forest issues regarding logging old-growth timber.*
2. *The jumbled shrubs, seedlings, young trees, and ferns under the mature trees of the canopy are called the* understory.
3. *The Townsend's chipmunk, a ground-dwelling species primarily inhabiting the forest floor, forages for grass seeds.*
4. *Broken-topped old-growth trees provide nesting places for raptors and woodpeckers.*

Temperatures are cool, rarely below –15°C or above 38°C. The Columbia River, one of the nation's mightiest, drains large portions of Washington and Oregon before emptying into the Pacific Ocean, as do hundreds of other rivers and streams that flow across this region. These streams defined routes by which settlers and loggers accessed the forests. They are also the paths taken by migrating salmon to spawn in the waters of their birth.

Forest Tiers

The temperate evergreen forest consists of three components or "layers": the canopy, the understory, and the forest floor. The *canopy,* the highest layer, is where the crowns of the forest trees meet to form a dense ceiling. Most temperate evergreen forest animals live in the *understory,* well beneath the canopy, where small trees and shrubs are found. The *forest floor* functions as a vast recycling center where dead plant and animal materials are converted to nutrients that are channeled back to the trees. Invertebrates are the main inhabitants of the forest floor.

Until recently, the importance of the forest canopy was poorly understood because of the technical difficulty in conducting scientific investigations so high off the ground. Today, research pioneers are using specialized equipment to uncover unique features and relationships within the canopy. The canopy has been described as the temperate evergreen forest's "engine" because many of the important chemical reactions that build fuels for life and growth through photosynthesis take place here. Light, carbon dioxide, and nitrogen are captured in the canopy trees' leaves and needles. Roots draw water and other nutrients from the soil and carry these through the trees' trunks to feed into the photosynthetic process. All of this results in the manufac-

BLM

Common golden chanterelle fungus. Fungi depend on rotting wood and leaf litter on the forest floor for nutrients.

ture of carbohydrates—the trees' food.

The canopy also controls the humidity and temperature of the forest, "insulating" the forest understory and floor from summer's light and heat, thereby keeping these lower forest tiers dark and damp. By contrast, during winter storms the treetops absorb the impact of the rain, allowing the drops of water to gently drip down to the lower layers, thus minimizing compaction and erosion. In the dry season (July through September), the canopy captures water from fog, with each conifer needle acting as a condensation point. The trees in temperate evergreen forests are vertically oriented so that rainwater is channeled toward their root systems. The canopy also contributes needles, leaves, and twigs to the organic matter that blankets the forest floor.

The dominant canopy species in the temperate evergreen forest is the Douglas fir, which can live to be 1,000 years old. The world's largest coastal Douglas fir tree is found on land managed by the Bureau of Land Management in the Coos Bay District of Oregon. Known as the Doerner fir, it is 100 m tall, 3.5 m in diameter, and 11 m in circumference. Sitka spruce, western hemlock, western red cedar, bigleaf maple, red alder, vine maple, and black cottonwood are also found in this rain forest.

The large, horizontal limbs of taller trees afford nesting places for the marbled murrelet, an endangered seabird that nests in coastal evergreen forests and feeds in offshore waters. This may be the only species to have adapted a direct dependency on both the temperate evergreen forest and the coastal marine environment. The role of the marbled murrelet in the temperate evergreen forest ecosystem—other than that of prey for larger animals—is unclear, although it is thought that the murrelet may be an indicator species for ecosystem health.

Canopy trees play another important role in the temperate evergreen forest ecosystem: They provide microenvironments that sustain a multitude of small species, from spiders and insects to fungus and lichens. Broken-topped trees and *snags*—trees that remain standing after they die—provide additional microenvironments such as nesting places for raptors and woodpeckers. Snags may stand erect for up to 200 years. In the first few years after a tree dies, beetles chew tunnels through the outer layers of wood and deposit wood-decaying fungi and bacteria in their feces. Woodpeckers feed on the beetles while bats rear their young under the loose bark of the snag. Over time, the wood softens sufficiently for cavity-nesting birds to set up residence. As more decades pass, only the largest branches remain attached to the trunk. When these branches finally fall off, the resultant gaps in the canopy allow sunlight to reach the forest floor, fostering the growth of species that require large amounts of light.

The canopy contains more than trees, however. It also hosts other forms of vegetation that boast interesting and unusual adaptations. Among these are *epiphytes* (Greek for "upon plants"), which grow in the forest's upper reaches unconnected to the ground, using other plants for physical support. Epiphytes, which include some mosses, ferns, and lichens, are not parasitic (i.e., they do not directly harm the host plant). Rather, these "air plants" absorb what they need from the air and the falling rain. By growing on other plants, epiphytes can take advantage of locations where competition for light is minimal.

Some epiphytes, such as nitrogen-fixing lichens, bring new nutrients into the ecosystem by capturing them from the air and converting them to forms that can be used by other plants. When epiphytes die, some of their parts fall to the forest floor, providing nutrients to be recycled; parts that are retained within the canopy in little pockets along branches or in the nooks of tree trunks act as soils that can support other plants. The evergreen huckleberry, for example, can sometimes be found exploiting such a pocket of soil 30 m or more above the forest floor. Other plants, such as bigleaf maples, can develop roots to tap these high-elevation pockets of soil and nutrients, offering opportunities for additional epiphytic growth.

Some of the plants and fungi found in the temperate evergreen forest canopy are parasitic. Though they take nutrients directly from trees and other plants, they ultimately contribute to the rich mix of organic substances in the canopy and, eventually, on the forest floor.

The animals that occupy the forest canopy play an important role in the temperate evergreen forest ecosystem, eating and breaking down materials into nutrients that can be recycled. The pileated woodpecker, for example, breaks up decaying wood in its search for carpenter ants. Other animals generate compounds that foster decay or protect a plant or tree from diseases or predators.

The temperate evergreen forest canopy has important functions that affect more than the forest itself. The trees absorb carbon dioxide and release oxygen, an exchange that helps offset the excess carbon dioxide released into the atmosphere when humans burn fossil fuels. By minimizing the impact of falling rain, the canopy lessens erosion on the forest floor and reduces the amount of sediment that runs off into streams. This helps keep the streams healthy and their

More Than Just Pretty Foliage

The evergreen forests of the Pacific Northwest were highly valued by the native peoples of this region. Western hemlock was used for making teas, salves, and medicines. Western red cedar was called the "tree of life," and was used for making baskets, rope, clothes, fish traps, canoes, shelters, spear poles, arrow shafts, coffins, dishes, and a red dye. Today, Douglas fir is the most important tree species in the United States. Wood from this species is used for construction and for making plywood composite boards and paper. The bark and needles of the Pacific yew contain taxol, a cancer-fighting substance.

Pacific yew (5–15 m is common height)

Douglas fir (80 m is common height)

western hemlock (30–50 m is common height)

western red cedar (30–55 m is common height)

SHELLY FISCHMAN

waters clean. The rivers and streams that run through the temperate evergreen forest carry fresh water and nutrient-rich debris to the coast, depositing essential nutrients and replenishing ocean waters. This debris is deposited near the shore creating estuaries, some of the most biologically rich environments on Earth. Some Pacific salmon spawn in such estuaries, while others stop to feed in them before continuing to the ocean.

The jumbled shrubs, tree seedlings, and ferns that collect under the towering canopy trees are collectively referred to as the understory. Most plants in the understory never grow to adult size because the dense canopy blocks out all but about 2 percent of the sunlight. Temperate evergreen forest understory vegetation provides excellent habitat and forage for insects and other forest animals which in turn contribute to the health of this layer by keeping rampant vegetation in check. In some places, the understory also provides food and other products used by humans, such as huckleberries, mushrooms, bear grass, and Spanish moss. A rich, complex understory is an important part of a healthy natural forest.

JOHN AND KAREN HOLLINGSWORTH, U.S. FISH AND WILDLIFE SERVICE

Olympic (Cascade) salamander. Salamanders hunt for food on the forest floor.

STEPHEN DOWLAN

The warty jumping slug (Hemphilia gladulosa) *is found west of the Cascade Mountains from southern British Columbia to the northern coastal mountain ranges of Oregon. Usually much smaller than the width of a dime, it may be found under mats of damp moss or in piles of rotting wood around stumps.*

The floor of a temperate evergreen forest contains a large number of nutrients that are constantly being recycled into organic compounds that are once again used by trees. Tree limbs, leaves, needles, and *duff*—a substance that develops from fallen bark at the base of trees such as the Douglas fir—support plant growth, provide habitat for insects and amphibians, and gradually decompose into a rich soil layer. Fallen snags and branches provide food, first for beetles and then for mites, termites, and carpenter ants. By eating dead leaves, needles, fungi, algae, animal droppings, carcasses, and other detritus and organisms, the forest's snails and slugs (including the native banana slug) play an important housekeeping role on the forest floor and help spread seeds and fertilizer throughout the ecosystem. Salamanders, spiders, and newts hunt insects on the forest floor and serve as prey for birds and other larger animals. Eventually, winter wrens, martens, and bears take up residence in the upturned roots and hollows of fallen trees.

Hundreds of varieties of mosses are found on the coastal rain forest floor. Plants such as bigleaf maples insert roots into the spongy moss to tap stored water and nutrients. During dry periods, mosses cease photosynthesis and lie dormant, becoming active again only when the rains begin anew.

Fungi, which have no chlorophyll and therefore cannot manufacture food via photosynthesis, depend on rotting wood and leaf litter on the forest floor for nutrients. Scientists have identified about 40 different kinds of mycorrhizal fungi attached to the root systems of Douglas firs. These specialized fungi form mutually beneficial relationships with the trees' roots, helping the roots resist disease and procure nutrients: The fungi extract phosphorous from the soil and "trade" it to the tree for carbon in the form of sugars. In one shovelful of forest soil are several kilometers of tiny Mycelia, the fungi's threadlike roots.

Mycorrhizal fungi produce mushrooms on the forest floor, including underground varieties known as truffles. These are eaten by small animals, which deposit feces containing fungal spores throughout the forest. These spores are then "absorbed" by the trees, which produce the sugars that the fungi need to survive. When trees are removed from the forest, mycorrhizal fungi and other soil organisms begin to die, impairing the soil's ability to store water and nutrients.

On the temperate evergreen forest floor, dense groundcovers, such as Oregon oxalis, can prevent tree seedlings from taking root, and fallen, decaying trees often act as "nurse logs" for new seedlings. Initially, the roots of these young trees hug the nurse log, so when the log decomposes and disappears, the roots of the now-established trees resemble stilts. A column of such trees standing in a row indicates grown-up seedlings that got their start on the same nurse log.

OREGON HISTORICAL SOCIETY, OR HI 49251 #333P225

Clastop Indian women (1894).

People of the Northwest Coast

People have lived in the Pacific Northwest for more than 10,000 years. Archaeological evidence shows that in the earliest sites, people focused their activities on estuarine habitats. By 5,500 years ago, substantial shell middens appear along the coast. Also, it is not uncommon for excavated sites to produce bones and shells representing hundreds of animal species. Among vertebrates, fish remains predominate followed by aquatic and marine birds, marine mammals, and in very small numbers, terrestrial mammals.

When first encountered by the Europeans, American Indian populations along the Northwest Coast were dense and diverse. In Oregon alone, languages from five major language families—Athapaskan, Chinookan, Alsean, Siuslaw, and Coos—were spoken. Such diversity, along with archaeological evidence, suggests a long and complex history for the peopling of the coast and for the development of coastal cultures.

European interest in this region was spurred by the search for the Northwest Passage, a waterway that could link the east and west coasts of North America. Fur traders were the first Euro-American visitors, followed by wave after wave of emigrants via the Oregon Trail after

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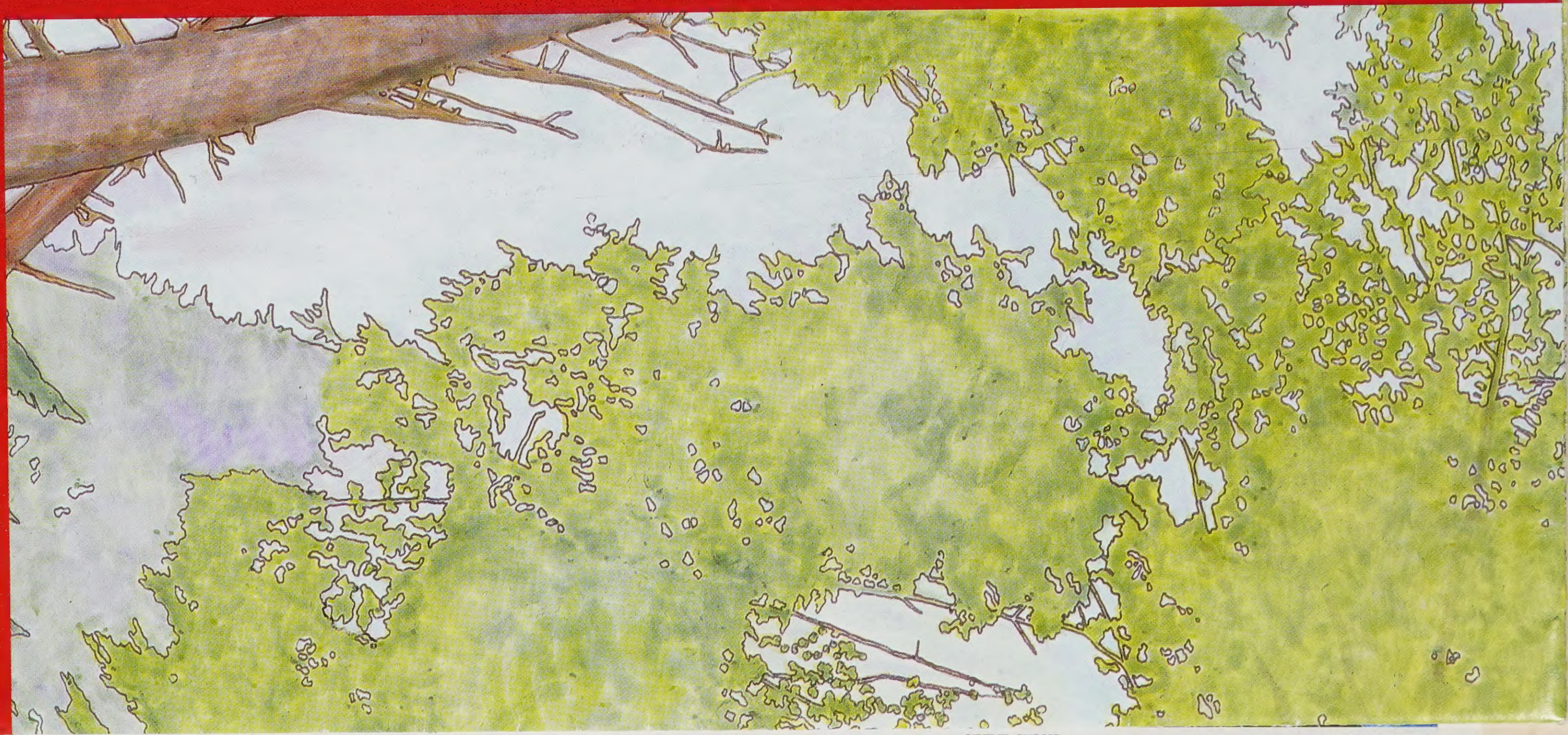

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The Emerald Ecosystem

Evergreen Forests of the Pacific Northwest

Department of the Interior, Bureau of Land Management

Artwork and associated research by Shelly Fischman

JOHN AND KAREN HOLLINGSWORTH,
U.S. FISH AND WILDLIFE SERVICE

1841. At that time the rain forest was viewed as remote and undesirable, and travel routes to the coast were difficult. Because farmland was limited, homesteaders practiced subsistence living—hunting, trapping, gathering, fishing, raising livestock, and gardening. This subsistence economy remains a prevalent lifestyle for area residents today.

With the start of the gold rushes in California, Alaska, and Oregon in the late 1840s and 1850s, the need for lumber to build camps, towns, and mines fostered a budding timber industry. Logging and milling of lumber also intensified in response to the needs of settlers. Initially, milled lumber had to be brought from the East Coast by ship. By the 1850s, local mills began to supply lumber for settlers' homes.

Intensive logging started in the 1860s, beginning the waxing and waning cycles of timber harvest that characterize this economy. Railroad expansion and homesteading in the late 1880s, rebuilding San Francisco after the devastating 1906 fire, and World War I all created an enormous demand for timber products. The Depression of the 1930s saw a decline in timber harvests and caused a surge of displaced people into the forest uplands to follow a subsistence lifestyle. World War II also caused an increase in the nation's need for timber products, and technological advances made for a more profitable industry. In 1939, the bulldozer was invented to pick up logs and quickly build dirt roads. Mills began to use trucks to haul logs out of the woods, replacing the earlier transportation methods of railroads and water flotation. Likewise, gasoline-powered chain saws came into regular use during World War II; by the end of the war, technology allowed logging to proceed at a much faster rate.

A strong, growing economic market for logs continued after World War II into the 1950s. As timber on easier-to-log terrain was depleted, new methods were developed. Today, helicopters and hot-air balloons are used to remove logs from hard-to-reach locations. Oregon still produces more timber than any other state in the continental United States, followed closely by Washington State.

Management Challenges

The thriving logging industry in the Pacific Northwest has not been without serious environmental consequences. Clear-cutting forests and using trucks on streamside roads cause rapid erosion. Sediment-clogged waters make streams inhospitable to native fish populations and reduce water quality for human communities. Many streams have been so degraded that once-dense salmon runs are all but gone. High timber harvests and the cutting of old-growth forests have threatened wildlife populations that depend upon functioning forest ecosystems. Especially threatened are the Northern spotted owl and the marbled murrelet. Even when logged areas are replanted, plant diversity is initially low—the complex ecological interworkings of a mature forest take hundreds of years to regenerate.

FRAN PHILIPEK

Yaquina Head, Oregon, shell midden excavation.

STEVE CYRUS

Road decommissioning (removing the hard surface to allow revegetation). Crooked Creek, Oregon.

Federal and state agencies and communities are working cooperatively to repair damage to the Pacific Northwest ecosystems. One complication of this effort is the patchwork of land ownership in some places.

Public land managed by the BLM is intermixed with land managed by the U.S. Forest Service and the state, and with land owned by large timber companies and individuals. This ownership pattern presents special challenges for land managers because every action taken on one parcel of land has the potential to immediately and directly affect the neighboring landowner. However, this ownership pattern does offer land managers opportunities for partnerships, shared resources, and cooperative work.

An example of one such partnership was an effort to improve fisheries in the checkerboard landscape of the Coast Range on Schoolhouse Creek in the Alsea River watershed. The BLM hired a contractor to install instream features to enhance spawning habitat for salmon. The adjacent private landowner, a timber company, planned and performed similar work on its part of the creek in conjunction with BLM. The timber company supplied logs for the BLM; in return BLM provided an equipment operator to place logs instream on the private portion. The result was 8 km of improved fish habitat.

Old-growth forest habitat and watershed issues have made management of federal forests in the Northwest contentious. By the early 1990s, with only 10 percent of the original old-growth forest remaining, controversy over the management of federal forests ran high. The result was a gridlock of lawsuits, court rulings, and polarized public debate. On one side were the timber commodity interests and communities with economic dependence on harvesting lumber. On the other side were those primarily concerned with maintaining old-growth forests and the species dependent upon them, especially the endangered Northern spotted owl.

Seeking a solution to the controversy, President Clinton held a Forest Conference in Portland in 1993, where citizens and scientists voiced their concerns. As a result of the conference, a team was assembled to prepare and assess alternative strategies that would apply an ecosystem approach to forest management, recognizing that

SHELLY FISCHMAN

Male sockeye salmon.

Time Bombs and Timber

SCIENCE & CHILDREN

The Mountain Blows Its Top

(These demonstrations were adapted from Volcanoes! Teaching Guide, *U.S. Geologic Survey.)*

Background: On May 18, 1980, Mount St. Helens erupted violently. At 8:32 A.M. Pacific Daylight Time, a magnitude 5.1 earthquake occurred about one kilometer beneath the volcano, triggering a catastrophic series of events that transformed Mount St. Helens' picturesque mountain landscape into a gray wasteland. The earthquake shook the walls of the volcano's summit crater and triggered many small rock avalanches. Within seconds a huge slab of the volcano's north flank began to slide, and small dark clouds began to billow out of the base of the slide. Plumes of steam and ash rose from the volcano's crater. As the avalanche of rock and ice raced down the mountain's north flank at more than 250 km per hour, a massive explosion blasted out of the north side of the volcano. This lateral blast became a fearsome torrent of ash and rock that outraced the avalanche. Probably no more than 20 to 30 seconds had elapsed since the triggering of the earthquake!

PHOTODISC

Mount St. Helens.

The eruption of Mount St. Helens was not a surprise to scientists who had been monitoring changes on the mountain for two months prior. For a volcano to erupt, magma must move to the Earth's surface. Increased earthquake activity, eruptions of steam and ash, and changes in the shape of the surface of the volcano all signal that magma is moving toward the surface. Inside the volcano, the solid rock that surrounds the molten rock often cracks from the increased pressure and causes earthquakes. Between March 20 and May 18, 1980, more than 10,000 small earthquakes were recorded beneath Mount St. Helens, and the larger earthquakes were felt by people living near the volcano. In addition to recording the distinct jolts characteristic of earthquakes, seismographs also detected continuous rhythmic vibrations called *harmonic tremors*—further evidence that magma was moving within the volcano.

As magma forced itself inside, the volcano swelled, or inflated. By early April, Mount St. Helens' north flank began to visibly bulge and crack. The bulge grew 2–3 m a day and moved outward about 150 m in two months. When the 5.1 magnitude earthquake shook Mount St. Helens on May 18, the bulge collapsed. The resulting avalanche was the largest volcanic avalanche recorded in historical times. In turn, the sudden removal of masses of rock and ice by the avalanche triggered an explosive eruption of the steam that was trapped in cracks and voids in the volcano and of the gases dissolved in the magma. Unleashed by the abrupt release of pressure, magma, rock, ash, aerosols, and gases exploded from within the volcano's north flank.

The Mountain Is Transformed

In a few minutes, Mount St. Helens' symmetrical cone was transformed—it was 400 m shorter and a gaping crater was gouged into its north side. An avalanche of rock, ash, ice, water, and fallen trees flowed as far as 9 km down the valley of the North Fork Toutle River. Debris dumped into Spirit Lake, raising the lakebed more than 940 m. The lake's cool, crystal-clear waters became a black stew of rocks, mud, and floating trees. Gone were 70 percent of the glaciers that had crowned the volcano; they were either melted by the heat of the eruption or carried away by the fast-moving avalanche. Trees up to 45 m tall were flattened and strewn like matchsticks in the wake of the lateral blast and debris-laden avalanche.

Eruptions Continue

Between May 18, 1980, and October 1995, Mount St. Helens produced at least 21 eruptions of magma and dozens of smaller gas explosions. All this volcanic activity took place in the bottom of the crater that was created by the eruption on May 18, 1980. Mount St. Helens is rebuilding itself as new lava squeezes up during each eruption to push aside old material from the surface of the dome. The volcanic activity that began in 1980 is not yet over.

By observing the following two demonstrations, students will understand why a bulge developed on the north flank of Mount St. Helens and why the avalanche triggered an explosive eruption.

Key teaching points:

1. The bulge that developed on the north flank of Mount St. Helens was evidence of changes occurring inside the volcano. Magma was moving closer to the surface and inflating, or *deforming,* the side of the volcano.
2. Scientists had been closely monitoring the growth of the bulge for nearly two months to try to forecast an eruption.
3. The 5.1 magnitude earthquake on May 18, 1980 shook the entire volcano. In turn, the shaking of the bulge area caused a sudden collapse of the volcano's north flank and triggered a large avalanche.
4. The removal of this large mass of rock caused a sudden release of pressure inside the volcano and a violent eruption occurred.

Materials:

- 1,500 mL Pyrex beaker
- damp sand
- several small balloons
- rubber bands
- Bunsen burner or hot plate
- straight pin
- bottle of soda water
- basin or bowl

Preparation:

Before class begins put about 1.25 cm of sand in the bottom of the beaker and level the surface of the sand. Partially inflate a balloon, secure it with a rubber band, and place the balloon on top of the sand in the beaker. Cover the balloon with sand to a depth of about 3.75 cm. Level the surface of the sand.

Introduction:

Begin the lesson by reviewing the series of events that occurred on May 18, 1980. Discuss the following events: the bulge that had been growing on the north side of the volcano for a month, the 5.1 magnitude earthquake that triggered the avalanche, and the avalanche that unleashed an explosive eruption—a *lateral blast.*

Demonstration 1: Why the bulge grew

1. Partially inflate a balloon. Ask students what would happen to the balloon if you were to heat the air inside the balloon? (The balloon would expand because the air expanded.) Explain that inflation caused a bulge to develop on the north side (*flank*) of Mount St. Helens.
2. Tell the students that the inflated balloon represents the magma chamber of Mount St. Helens (See Figure 1).
3. Show the prepared beaker to the students and tell them there is a partially inflated balloon inside the beaker. Place the beaker on the Bunsen burner or the hot plate. Heat the beaker until the balloon begins to expand. (The surface of the sand should begin to bulge.) (See Figure 2.)
4. Students should observe and record the changes in the shape of the surface of the sand. What happens to the "land" as the "magma chamber" expands?

Demonstration 2: Why the avalanche triggered the explosive eruption

1. Ask students what would happen if they were to stick a pin into the balloon. (It would pop.) Why does it explode? (The balloon bursts because the pressure inside the balloon is suddenly released and the gases can escape rapidly.) Burst the balloon with the straight pin.
2. Ask students what happens when they open a bottle of soda. (It makes a fizzing sound because the carbon dioxide, CO_2, in the soda escapes.) Demonstrate this over a bowl or basin by shaking a bottle of soda water and then opening it. (The soda water "erupts" out of the bottle.)
3. Compare the soda bottle to a volcano's magma chamber. As long as the top is on the bottle there is no eruption. Compare the rock and ice that was unloaded by the avalanche to the soda cap. When this rock and ice "cap" was suddenly removed, the pressure inside the volcano was suddenly released and the volcano erupted.

Figure 1.

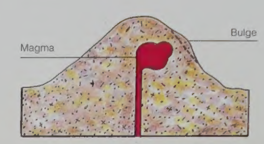
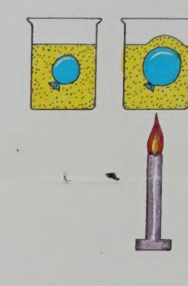


Figure 2.



Salamanders and Slugs and Spruce, Oh My!

(foldout guide)

Welcome to an autumn scene in the Emerald Ecosystem. In the evergreen forests of the Pacific Northwest flora and fauna abound at all levels.

We are in a clearing of the Coastal Range region of this ecosystem. Near the forest floor, purplish Oregon grapes flank a sword fern frond hosting a banana slug. On the ground nearby, a copper-brown ensatina salamander is poised on a piece of tree bark. Alongside the bark lies a Sitka spruce cone under a frond of maidenhair fern. Under a brilliant red mushroom (Amanita muscaria, *pretty—but poisonous) a lumpy-backed snail eater beetle is looking for a meal near a patch of yellow* Ramaria *fungus.*

Farther in the distance a red-backed vole peeks its nose out from behind an Amanita *stalk, which is nestled among more sword ferns. Beyond them,* Rhododendron *bushes flourish. To the left, you'll see a black-tailed deer and a snag with ferns growing within and around it. Close by, and near some lady fern, lurk a northwestern garter snake and a furry, weasel-like pine marten. Travel a bit to the left and you'll see, under a branch of* Rhododendron, *another snag that is home to ferns,* Marasmius bresadolae *mushrooms, and a Pacific tree frog.*

Farther back in the clearing is a fallen tree acting as a nurse log to a western hemlock sapling. A vine maple, its leaves yellow in fall color, rises up from the forest floor. Swooping down from the canopy, a spotted owl seeks a meal of voles. Off in the distance and also on the lookout for food, a bobcat perches on an outcrop. Soaring up to the sky are western hemlock and Sitka spruce trees, their vast branches forming a canopy over the forest clearing. Look closely and you can see epiphytes*—air plants—nestled in some of their branches.*

STEPHEN DOWLAN

The Malone jumping-slug (Hemphilia malonei) *was known to live in only six locations and numbered fewer than 50 individuals prior to 1997. Recent surveys in forested habitat have found the slug to be locally common in southwest Washington and northwest Oregon, especially where there are large old rotting logs on the forest floor.*

Transportation of Logs Using a Single-Span Skyline Yarding System

Bibi Booth, John Caruso, and Frances Philipek

In the logging profession, *yarding* refers to the transportation of logs from the mountainside where they were cut to a level location (*landing*) where they can be stacked (*decked*) and loaded onto a truck or train for hauling from the forest. The two basic forces that any yarding system must overcome are *gravity* and *friction.*

What Is a Single-Span Skyline Yarding System?

On many mountain slopes, loggers use a *single-span skyline* yarding system to transport logs. In this system, logs are attached by a vertical cable (*choker*) to a *carriage,* which slides horizontally on wheels along the *mainline,* a movable cable attached to the *skyline,* which is a cable strung between two upright *spars* (cable anchors). The carriage allows logs to be transported along the cable up the mountainside to the landing (see diagram). A motor provides the power to move cables in this type of system.

Simplified, idealized single-span skyline yarding system shown operating on a single mountain slope. In practical applications of this logging system, the tail of the skyline cable would typically be fastened on a tree stump or other anchor on an opposite mountain slope.

The objective of this type of logging operation is to lift logs as high as possible above the mountain's surface to minimize damage to ground soil, vegetation, and the logs themselves. The height of the spars, the elevation of spar support points, the distance between the spars, the steepness of the mountainside, and the weight and size of the logs all affect the percentage of *loaded deflection* (sag in the skyline cable) that can be accommodated before the logs or the skyline will begin to drag on the ground. Because natural ground is uneven, bumps and dips in the mountainside's surface must also be taken into account.

How Do You Determine the Best Arrangement of Components?

Today's loggers use computers to determine the best arrangement for single-span skyline yarding systems; however, before computers became commonplace (1980s), loggers created simple "chain and board" models of a mountainside to make their determinations. By experimenting with variations of the model's components, the loggers could decide which arrangement would allow the heaviest load to be transported the farthest distance up a mountain at the lowest cost with the least damage to the ground. These models also helped them determine whether skyline logging of a particular mountainside was feasible at all.

What Is the Best Arrangement?

The optimal arrangement of the components of a single-span skyline yarding system differs from one mountain to the next because of differences in steepness and ground irregularities. For a given mountainside, the best arrangement for the single-span skyline yarding system is one that can accommodate a lot of loaded deflection in the cable line and still allow the heaviest logs to clear the ground surface. At a minimum, the system must transport the heaviest logs up the slope without allowing the skyline cable or the log's *leading edge* (the uphill-facing edge) to touch the ground at any point. If these conditions are not met, the single-span skyline system will not work to transport logs from the desired stretch of mountainside. In addition, the best single-span skyline yarding system will function over a span of at least 300 m in horizontal distance and will allow erection of the shortest possible spars, permitting logging of a large area at the lowest possible expense.

The single-span skyline yarding system functions much like an elongated version of a motorized crane, such as those used in building construction. Other mechanical systems that apply the same principles include the winches on tow trucks, and the block-and-tackle systems used in construction and other operations that require lifting heavy objects.

Why Are Logs Transported Up Mountainsides?

Please note that, in this type of system, logs are transported *up* the side of the mountain—*against* the force of gravity—to the landing. Though it is natural to think that downward transportation (working *with* gravity) would be easier, the reasons for upward transportation in logging are very practical. In order to minimize damage to the logs and remaining trees, mountainside trees are *felled* so that their tops either fall toward the top of the mountain or to the side of the path of the skyline. The trees actually fall a lesser vertical distance to the ground when felled in these directions rather than downhill. Typically, felling to the side results in a herringbone arrangement of logs on the mountainside. The choker cable then lifts the trees by their bottoms, so that the greater proportion of log weight is suspended close to the carriage. The uphill direction of transport prevents the trees from rotating in the process of being lifted. Also, uphill transportation of logs allows operators more control of the logs' weight; if the logs were coming downhill, their momentum might pose a risk to human life and logging machinery.

Moving a Load

This activity demonstrates to students how loaded deflection changes when you change the height of a load.

Materials:

- 16 m length of rope
- 7.5–11 kg weight
- stable chairs or tables

Procedure:

1. Attach the weight to the middle of the rope. Set the weight on the ground. Have two students (one on each end of the rope) stretch the rope (from waist level) until the weight has been raised 0.3 m off the ground.
2. Place the weight on the seat of a chair or on a low table and have the same students pull the rope from waist level to raise the weight 0.3 m above the chair seat or table.

Discussion:

1. Was it more, less, or equally difficult to raise the weight 0.3 m (obtain 0.3 m of lift) when the weight was raised from the floor versus from the chair?
2. What changes could be made to this simulation to make it easier to obtain 0.3 m of lift with the weight on the chair? (Try having the students who are doing the lifting stand on chairs or tables, or have them pull the rope from shoulder height rather than waist height.)
3. Is it easier or harder to obtain 0.3 m of lift if the students are positioned closer to the weight? Is it easier or harder when one student pulls while standing on a chair or table and the other student pulls from ground level? How about when both students are on chairs or tables?

"Chain and Board" Activity

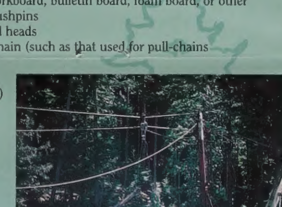
The "chain and board" approach allows loggers to determine the suitability of a mountainside for log transport without the use of complicated mathematical formulas or computers. In this activity, students will design a model of a single-span skyline yarding system for a hypothetical mountain, adjusting various components of the system to achieve the most efficient arrangement for log transportation. They may find that some mountains simply cannot be logged with a single-span skyline yarding system without damaging the ground or cannot be logged over a great enough horizontal distance (at least 300 m) to be cost-efficient. Keep in mind that this activity simulates a hypothetical situation in which single-span skyline yarding is performed on one portion of a single mountainside. Normally, single-span skyline yarding involves anchoring the cables across a valley from the mountainside to be logged. This arrangement increases the amount of deflection that can be accommodated by the system. (Note: Students should work in groups of four. Also, to simplify this experiment, only the skyline cable is represented. The mainline cable is not represented, and its functions are combined with those of the skyline cable.)

Students follow a planning/design procedure used by loggers to determine:

- whether or not a particular mountainside can be logged with a single-span skyline yarding system,
- how to best construct a single-span skyline yarding system to transport the most logs and minimize environmental damage,
- the maximum load that the system can transport up a particular mountainside.

Materials for each group of students:

- one 1 m x 1.25 m or larger sheet of graph paper
- one 1 m x 1.25 m or larger corkboard, bulletin board, foam board, or other board suitable for inserting pushpins
- 7–10 pushpins with elongated heads
- 1 m length of beaded metal chain (such as that used for pull-chains on light sockets)
- one standard paper clip (approximately 0.9 cm x 4 cm)
- one narrow, cylindrical eraser (such as the type used as eraser refills for mechanical pencils); using the scale you have selected (see Procedure, Preparing the Board, Step 3 below), cut the eraser to a length representing 12.5 m
- meterstick or ruler with metric units
- one 3 cm length of drinking straw



JOHN C. STEWART

Single-span skyline yarding systems enable loggers to remove trees from steep slopes.

Procedure:

I. Preparing the board
- *Step 1.* Place the corkboard, foam board, or bulletin board flat on a table with the 1.25 m side running left to right and the 1 m side running up and down.
- *Step 2.* Attach the graph paper at the four corners of the board with pushpins; if necessary, anchor with additional pins at top, bottom, and sides.
- *Step 3.* Select a scale to use to create your model. For example, for a 1 m x 1.25 m board, a scale of 1 cm = 3 m works well. Note: the horizontal and vertical scales must be the same. Show your scale in a legend block in one corner of the graph paper.
- *Step 4.* Starting near the upper left corner of the graph paper, draw a line down to the lower right hand corner to represent the profile of one side of a mountain. Remember, the profile should not be an even line or curve because natural mountainsides have bumps and dips and often change steepness from section to section.

II. Creating the model of the single-span skyline yarding system
- *Step 1. Drawing the spars:* Draw two vertical lines whose bottom ends touch the surface of the mountainside; one line should be near the top of the slope, the other near the bottom. These represent the headspar and tailspar of the logging transport system. Typically, spars are between 16 m and 27 m tall; make sure you draw your spar lines to scale. For example, if you are using a scale of 1 cm = 3 m, your spar lines should be between 5 cm and 9 cm high. The distance between spars can vary; position the spars at least 300 m apart, according to your scale.
- *Step 2. Determining the spar connection points for the skyline cable:* Measure the width (narrow dimension) of your paper clip. Now, measure that distance down from the top of each spar line and place a dot at each of those points. On the lower spar line, mark a second dot 3 m–4.5 m below the first dot, measured to scale.
- *Step 3. Drawing the chord and midspan line:* Draw a straight line between the dot on the upper spar and the *lower* dot on the lower spar. These two dots represent the support points for the skyline cable. The straight line between them, called the *chord,* represents the shortest distance between these points. Now, using a yardstick or ruler, mark the midpoint of the chord and draw a straight vertical line between the midpoint and the mountainside. This is the *midspan* line.
- *Step 4. Erecting supports for the skyline—stringing the skyline:* Firmly insert pushpins at the two marked skyline support points on your spars. (Remember, on the tailspar this is the *lower* dot.) Insert a third pin a couple of centimeters downslope from the lower support point; this will be used later to adjust the tension on the skyline. Secure the skyline (chain) at the headspar support by knotting it around the head of the pushpin. Pass the skyline gently over the tailspar support and secure it to the pushpin located downslope from the tailspar support. Now, raise your board to an upright position and lean it against a wall or other support.
- *Step 5. Constructing the carriage apparatus:* Partially unbend one end of your paper clip to create a straight section that forms a right angle with the body of the paper clip. Beginning at the end of the straightened section of the paper clip, gently slide the drinking straw onto the paper clip. Push the point of the straight end of the paper clip partly through the narrow width of the eraser near one end (see diagram). The body of the paper clip represents the carriage; the straightened section of the paper clip represents the choker, and the eraser represents a log.
- *Step 6. Attaching the carriage to the skyline cable:* Temporarily remove one end of your chain, threading it through the straw, and reattach the link of the chain to its anchor. The carriage must be able to move freely on the skyline. (Note: If you have trouble maintaining attachment of your chain on the pins, one group member should hold the chain at the headspar support pin and another student should hold the chain at the pin downslope of the tailspar.) Slide the carriage back and forth along the skyline a few times to test its freedom of movement.
- *Step 7. Adjusting the skyline cable for ground clearance:* For the transport system to function successfully, your skyline cable must be situated such that neither the skyline cable nor the leading edge of the log touches the ground at any point along the log's path up the slope. The log does not have to be fully suspended, but its leading edge must clear the ground. Slide the carriage the length of the skyline cable, maintaining the carriage in a horizontal position along the cable at all times. Whenever the skyline cable and/or log dips below the ground profile, adjust the tailspar pin up or down on the spar line so that the skyline cable and log just clear the profile along the entire distance between spars. Check the entire span between the spars in this manner. When you have determined that there is clearance along the entire span, detach the end of the skyline from the lowermost pin and anchor it to the tailspar pin at the support point.

III. Measuring the loaded deflection distance and the allowable percentage of loaded deflection that can be accommodated on the slope:
- Move the carriage and log to the midspan position on the skyline cable, and measure the vertical distance between the skyline cable (chain) and the chord (the straight line between spars). This midspan vertical distance is the amount of loaded deflection.
- Measure the chord between your spar supports. To obtain the allowable percentage of loaded deflection, divide the loaded deflection by the chord distance and multiply this figure by 100. For example, if loaded deflection is 15.25 m and chord distance is 300 m, the allowable percentage of loaded deflection is 15.25 m ÷ 300 m x 100, approximately 5 percent.

IV. Discussion:
- Were you able to transport logs up your mountainside? If not, what could you have changed to make log transportation possible?
- Compare your results with those of other groups that used steeper or gentler slopes, more even or bumpier ground surfaces, different weights of chain, higher spars, etc. What differences existed in the ways their systems functioned?
- Which elements of this model could be altered to change the amount and allowable percentage of loaded deflection and other system characteristics?
- Try these variations:
  - raise or lower the height of the headspar and/or tailspars
  - increase or decrease the distance between the spars
  - change the ground profile (this is equivalent to changing your spar locations or selecting a different mountainside profile)
  - use a heavier or lighter chain
  - use a lighter load (break the eraser in half lengthwise, use a smaller eraser, and/or use a smaller paper clip, etc.)
  - use a heavier load (attach two erasers)
  - try arranging a single-span skyline system in which the two ends of the skyline are separated by a canyon, river, fragile habitat, etc. (Note: In this case, the tail of the cable should be anchored close to the ground, not on a spar.)

Logging Vocabulary

carriage: a wheeled device to which the choker is attached; the carriage slides along the mainline cable (Note: The carriage and choker are attached directly to the skyline in the "Chain and Board Activity.")

choker: a short cable, running vertically down from the carriage, to which a log can be attached

chord: a straight line between the skyline support points on the spars

deflection: sag; even when it is not transporting logs, a skyline cable always experiences some deflection

headspar: the spar that is farther up the slope

landing: the level area at the top of the slope where logs are stacked; from this area, logs are loaded onto vehicles for hauling

leading edge: during uphill transportation, an edge on the uphill-facing end of the log

loaded deflection: the amount of sag in the skyline cable that is caused by the weight of the log and carriage; the greater the log weight, the greater the loaded deflection of the skyline cable

mainline: the cable that moves the carriage and is parallel to the skyline cable (not modeled in the "Chain and Board Activity")

midspan: a vertical line drawn between the midpoint of the chord and the surface of the slope

single-span skyline: a skyline without intermediate supports, i.e., supported only by a headspar and tailspar or other tail anchor

momentum: the property of a body that determines the length of time required to stop its motion

skyline: a heavy cable, suspended between the headspar and tailspar, used as a track along which the mainline, carriage, choker, and log move up the slope

spar: one of two upright poles to which the skyline cable is anchored

spool: a large cylinder around which cable is wrapped to control slack

tailspar: the spar that is farther down the slope

yarding: the process of conveying logs to a landing

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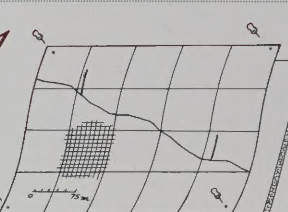

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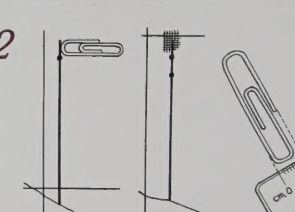

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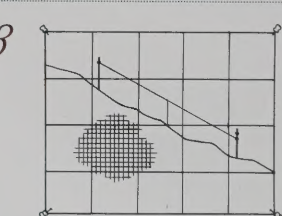

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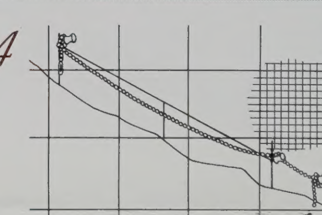

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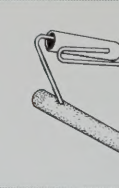

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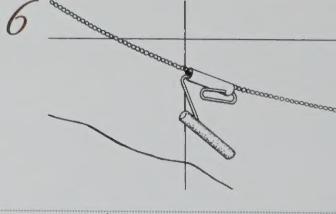

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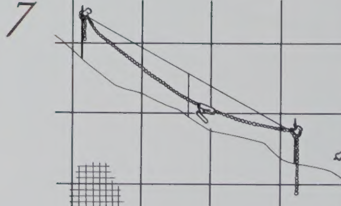


Foldout front designed by Graves Fowler Associates, Rockville, Maryland; and Shelly Fischman of BLM.

1841. At that time the rain forest was viewed as remote and undesirable, and travel routes to the coast were difficult. Because farmland was limited, homesteaders practiced subsistence living—hunting, trapping, gathering, fishing, raising livestock, and gardening. This subsistence economy remains a prevalent lifestyle for area residents today.

With the start of the gold rushes in California, Alaska, and Oregon in the late 1840s and 1850s, the need for lumber to build camps, towns, and mines fostered a budding timber industry. Logging and milling of lumber also intensified in response to the needs of settlers. Initially, milled lumber had to be brought from the East Coast by ship. By the 1850s, local mills began to supply lumber for settlers' homes.

Intensive logging started in the 1860s, beginning the waxing and waning cycles of timber harvest that characterize this economy. Railroad expansion and homesteading in the late 1880s, rebuilding San Francisco after the devastating 1906 fire, and World War I all created an enormous demand for timber products. The Depression of the 1930s saw a decline in timber harvests and caused a surge of displaced people into the forest uplands to follow a subsistence lifestyle. World War II also caused an increase in the nation's need for timber products, and technological advances made for a more profitable industry. In 1939, the bulldozer was invented to pick up logs and quickly build dirt roads. Mills began to use trucks to haul logs out of the woods, replacing the earlier transportation methods of railroads and water flotation. Likewise, gasoline-powered chain saws came into regular use during World War II; by the end of the war, technology allowed logging to proceed at a much faster rate.

A strong, growing economic market for logs continued after World War II into the 1950s. As timber on easier-to-log terrain was depleted, new methods were developed. Today, helicopters and hot-air balloons are used to remove logs from hard-to-reach locations. Oregon still produces more timber than any other state in the continental United States, followed closely by Washington State.

Management Challenges

The thriving logging industry in the Pacific Northwest has not been without serious environmental consequences. Clear-cutting forests and using trucks on streamside roads cause rapid erosion. Sediment-clogged waters make streams inhospitable to native fish populations and reduce water quality for human communities. Many streams have been so degraded that once-dense salmon runs are all but gone. High timber harvests and the cutting of old-growth forests have threatened wildlife populations that depend upon functioning forest ecosystems. Especially threatened are the Northern spotted owl and the marbled murrelet. Even when logged areas are replanted, plant diversity is initially low—the complex ecological interworkings of a mature forest take hundreds of years to regenerate.


FRAN PHILIPEK

Yaquina Head, Oregon, shell midden excavation.


STEVE CYRUS

Road decommissioning *(removing the hard surface to allow revegetation). Crooked Creek, Oregon.*

Federal and state agencies and communities are working cooperatively to repair damage to the Pacific Northwest ecosystems. One complication of this effort is the patchwork of land ownership in some places.

Public land managed by the BLM is intermixed with land managed by the U.S. Forest Service and the state, and with land owned by large timber companies and individuals. This ownership pattern presents special challenges for land managers because every action taken on one parcel of land has the potential to immediately and directly affect the neighboring landowner. However, this ownership pattern does offer land managers opportunities for partnerships, shared resources, and cooperative work.

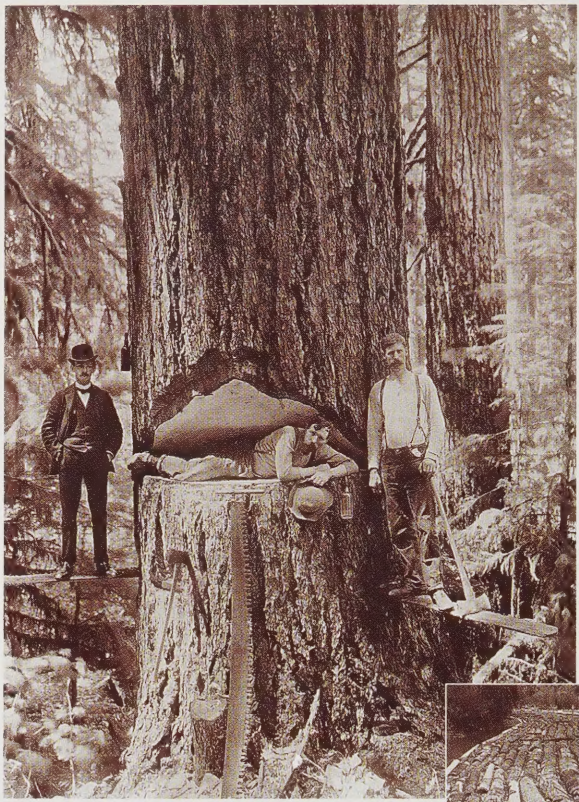
An example of one such partnership was an effort to improve fisheries in the checkerboard landscape of the Coast Range on Schoolhouse Creek in the Alsea River watershed. The BLM hired a contractor to install instream features to enhance spawning habitat for salmon. The adjacent private landowner, a timber company, planned and performed similar work on its part of the creek in conjunction with BLM. The timber company supplied logs for the BLM; in return BLM provided an equipment operator to place logs instream on the private portion. The result was 8 km of improved fish habitat.

Old-growth forest habitat and watershed issues have made management of federal forests in the Northwest contentious. By the early 1990s, with only 10 percent of the original old-growth forest remaining, controversy over the management of federal forests ran high. The result was a gridlock of lawsuits, court rulings, and polarized public debate. On one side were the timber commodity interests and communities with economic dependence on harvesting lumber. On the other side were those primarily concerned with maintaining old-growth forests and the species dependent upon them, especially the endangered Northern spotted owl.

Seeking a solution to the controversy, President Clinton held a Forest Conference in Portland in 1993, where citizens and scientists voiced their concerns. As a result of the conference, a team was assembled to prepare and assess alternative strategies that would apply an ecosystem approach to forest management, recognizing that


SHELLY FISCHMAN

Male sockeye salmon.



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Timber felling (1905–1910), Oregon.

viable communities with sustainable economies are a component of a healthy ecosystem. The result of the team's work is the Northwest Forest Plan, which applies to lands administered by the BLM and U.S. Forest Service.

As part of the Northwest Forest Plan, about 80 percent of the Northwest federal forests are now reserved from logging and are managed to protect habitat and forest species, while other areas are allocated for timber harvest. A buffer of land is reserved from use along all streams, ponds, and lakes to retard sediment flow into the water and to keep the streams shaded and water temperatures cool. The time frame for improvements on the landscape will be measured in hundreds of years. The goal of protecting and enhancing the old-growth ecosystem involves several related efforts—surveys, inventories of species, streamside improvements, and road closings.

Thousands of kilometers of roads weave through the forest, most of them originally built to access harvestable timber and without consideration for engineering methods that would have minimized erosion. The roads themselves continue to be a cause of excess stream sediment from erosion- and road-related landslides. Likewise, ready access allows more people into remote areas and increases the risk of unwanted fire. For all of these reasons, many roads are being *decommissioned*. All the roadbed material is removed, and the cut-and-fill areas are reshaped to replicate the original contours of the land. The area is then planted with seeds and seedlings.

Stream restoration methods include placing structures such as large rocks and logs in the stream, and replacing culverts so that they do not impede fish from moving through the stream. Instream structures slow down the water and create quiet pools. Fish eat insects that hatch in these pools and young fish are reared in them. Slow-flowing water also allows the streambed to develop the gravel base necessary for the protection of fish eggs. Water quality and aquatic habitat both improve through these restoration actions.

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Yeon and Pelton logging company log raft (c. 1905), Rainier, Oregon.

The Northwest Forest Plan seeks to maintain both a healthy ecosystem and viable communities. However, placing large areas of forest in reserve status means that less timber is available for harvest, leaving many local timber-dependent communities with significant unemployment problems. To help remedy this situation, the Ecosystem Workforce Program (EWP) was created to link federal and state agencies in a program that maintains a highly skilled, specialized workforce within the local communities. The goal includes creating long-term, high-skill and high-wage jobs in the newly established ecosystem management industry.

The EWP has taken different routes to success. Agreements were signed between a variety of government and private entities to bring together complementary programs for training, worker identification and recruitment, ecosystem management contracting, and job needs in watershed restoration. As the trained workforce grew, partner agencies sought innovative ways to bundle contract work across agencies to create long-term jobs. As a result, work is retained within local areas, employment durations have increased, and pay and benefits meet family needs.

In addition to changing the nature of people's work, the Northwest Forest Plan has also changed how people recreate. For example, some campgrounds, many of which were built in the 1930s within stands of large old trees, may need to be closed because they are in areas designated as *riparian reserves* (streamside areas). Continued use of these campgrounds could frustrate efforts by land managers to restore the areas, which are critical to water quality and ecosystem health. In other campgrounds, routine maintenance has become more complicated. For example, as trees mature they are susceptible to disease and insects and they may lose branches or topple over in windstorms, presenting a public safety issue. Before implementation of the Northwest Forest Plan, it was a simple process to remove the trees or branches with minimal impact on public use of the campground. Now, a variety of studies must be completed before such maintenance can take place. Until the studies are completed and the proposed actions approved, affected portions of the campgrounds may be closed to the public for months instead of days.

Ski area expansion is another issue that stirs debate. Established ski resorts in the Cascades wish to expand their runs to accommodate snowboard enthusiasts. Yet expansion is unlikely where this would mean sacrificing parts of the forest reserves or impacting aquatic resources. Resorts must modify even their established operations to meet standards for forest and aquatic health.

While the questions of whether and how much to log the federal forests have been answered by the Northwest Forest Plan, other uses of the forest pose the same challenge—how to incorporate the needs of both human communities and ecosystem health. Science can inform decision makers about certain consequences of their choices, but it will take the cooperation of all who have a stake in and care about this unique ecosystem to ensure that it thrives. The majesty of the Northwest Forests and the remarkable web of life that supports them are a legacy that future generations should have the opportunity to experience.

Stop the Flow!

This activity simulates protected versus unprotected streamsides. Students compare and contrast the situations and analyze the effects on aquatic systems.

Background: A key aspect of watershed restoration and aquatic habitat improvement is reducing sediment flow into streams. Logging on slopes and road construction also contribute to erosion. The best way to keep landslides and surface sediment from reaching streams is to leave a buffer zone of vegetation in place on either side of the stream.

Question: What is the difference between the amount of sediment found in a stream with a buffer zone as opposed to a stream with no buffer zone?

Materials: cookie sheet, aluminum foil, lightweight cotton cloth, potting soil or dirt, sod, a water bottle fitted with a sprinkler head or sprayer.

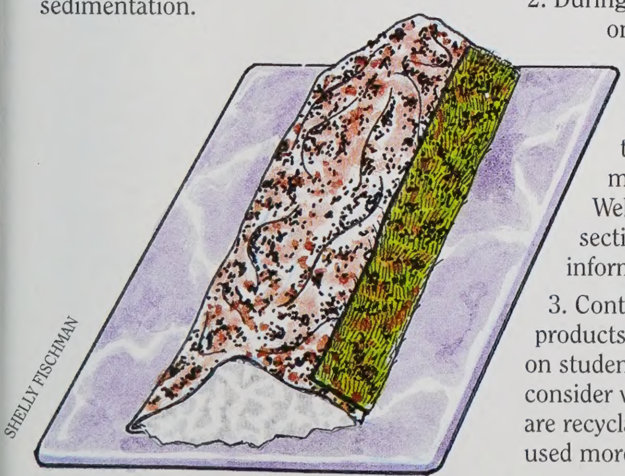
Procedure:

1. Using crumpled aluminum foil, make a hilly landform shape to represent *deforested slopes*. The "hill" should have a crest but should not be too steep on the sides. Place it lengthwise in the center of the cookie sheet; the aluminum foil should reach the short ends of the cookie sheet. Loosely drape the cloth over the hill. Along one long edge, tuck the edges of the cloth under the foil. Along the other long edge, place the cloth edge under a strip of sod that is about 5 cm wide. Scatter soil over both slopes.

2. Explain to students that the model simulates deforested slopes with streams on either side. The side with the sod simulates a stream with a buffer zone. Ask students to predict and observe which stream will have the most sedimentation.

3. Using the bottle of water fitted with either a sprinkler head or sprayer, douse the hill with water, getting even amounts of water on both sides. The soil should "erode." Students should notice that the buffer zone stops the sediment from going into the stream, while the unbuffered side unloads abundant sediment into the stream.

4. Using information from the article, discuss with students the effects of sedimentation on aquatic species and water quality.



Stop the Flow.

What Is Wood?

Students list products made from wood, add to the list through research, and analyze their list to differentiate two categories of wood products.

Background: Wood products are essential to our lifestyle and survival. Many products contain components derived from wood that may not be obvious. Wood is a renewable resource and much of our wood today comes from tree farms. These are not really forests, for they lack the ecosystem relationships of a natural environment; rather they are *monoculture crops* (single species). Forests also provide a great deal of our nation's wood supply. On average, every person in the United States consumes the equivalent of one tree a year in wood products, including 306 kg of paper.

Question: What wood products do we use in our everyday lives and how can we make wiser use of this natural resource?

Procedure:

1. Ask students to list items in their daily lives that are made or derived from wood. You may want to share some ideas from the next column.

2. During a class discussion, make one list on the board from the students' lists. Leave the list where it is visible and give students the opportunity to research other products made from wood. Some of the Web sites listed in the Resources section of this article provide such information.

3. Continue the discussion, adding new products to the class list based on students' research. Now have students consider which wood products are recyclable and which could be used more efficiently.

From a tree:

guitars	railroad ties
colognes	animal feed additives
baby food	paper and cardboard
rayon fabric	tea bags
floor tiles	sausage casings
toothpaste	shoe polish
football helmets	oil filters
computer casings	corkboards
luggage	roofing
cleaning compounds	vinegar
insecticides	fish food
rubber tires	Christmas trees
photographic film	ink
cosmetics	diving boards
boardwalks	golf balls
chopsticks	paint remover
home insulation	cascara bark
firewood	

Floral industry materials:

moss	cones
salal	transplant shrubbery
beargrass	

Three Volcanoes

This demonstration illustrates the three types of volcanoes. Students predict the types that will form from the demonstration and compare the results with illustrations. *(This demonstration is adapted from* Volcanoes! Teaching Guide, *U.S. Geological Survey.)*

Background: There are three types of volcanoes distinguished by the kind of material that erupts from them and how it builds up over time. *Shield volcanoes* are low and gently-sloping; they eject a fluid magma that flows slowly. *Stratovolcanoes* (sometimes called *composite volcanoes*), such as Mount St. Helens, are shaped by built-up layers of thick lava alternating with *tephra,* the airborne fragments of magma that range in size from fine ash to giant boulders. Stratovolcanoes are the classic cone-shaped volcanoes. *Cinder cones* are small volcanoes containing lava that, when airborne, forms into cinders and then falls back to Earth in a cone shape around the volcano's lava vent.

Question: How do different types of volcanoes form?

Materials: three pie plates; three one-cup measuring cups; two cups cat litter, sand, or sugar (simulating tephra); two cups chilled molasses or thick mixture of plaster of Paris (simulating lava); a protractor; a metric ruler

For the Classroom

Procedure:

1. Explain to students the different types of volcanoes and draw their shapes on the board. Use the illustrations labeled master sheets 1.1, 1.2, and 1.3, found at http://www.usgs.gov/education/learnweb/volcano/lesson1.pdf as a guide. Tell students which materials represent tephra and lava. As you prepare to make each of the three models, students should predict which type of volcanoes the materials will form.

2. In one pie plate, from a height of about 50 cm, slowly pour one cup of the tephra material. In another pie plate, from a height of about 20 cm, slowly pour one cup of lava material. In the third pie plate, alternate layers of tephra and lava, again from a height of about 20 cm. Students should observe the shapes as the tephra and lava are poured.

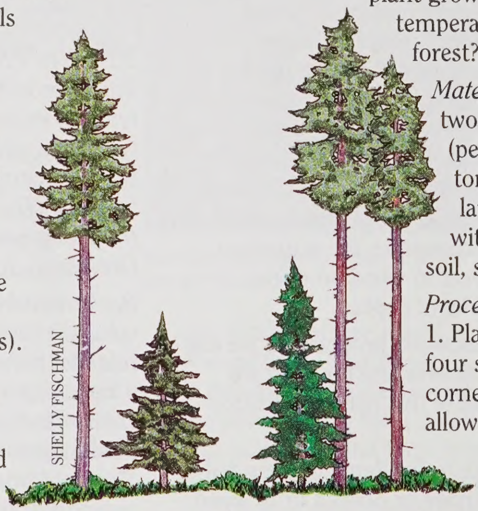
3. Let students compare the shapes of the models with the illustrations and discuss how the materials ejected from a volcano determine the shape of the volcano. Use a protractor to measure the slope angles of the three types of volcanoes. Let students look at photographs and Web sites showing the volcanoes in the Northwest and determine which kind of volcanoes are found there (strato-volcanoes). The following Web sites include images of volcanoes in the Pacific Northwest: http://vulcan.wr.usgs.gov and http://www.nps.gov/mora/.

A Crowd of Plants

Changing the space allocated to plants simulates conditions in the rain forest. Students observe, record, compare, and contrast the changes and apply the knowledge from this experiment to the rain forest situation.

Background: Plants need air, water, sunlight, soil, and room to grow. Plants that grow too closely together compete with each other for the other essentials of plant life and are often stunted and weak, making them especially prone to disease, fire, and windfall. In the rain forest, few plants can successfully germinate and grow under the old-growth's dense canopy, which blocks out sunlight. New plants can get a vigorous start when an old tree dies or when disease, fire, or windfall create an opening in the canopy through which sunlight penetrates.

Question: How does shade affect new plant growth in the temperate rain forest?

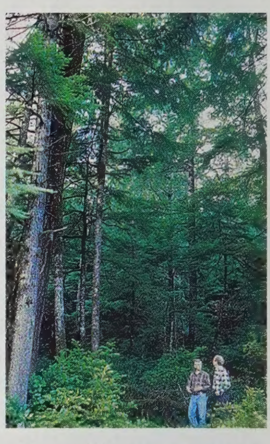

SHELLY FISCHMAN

The three layers of the temperate evergreen forest: the canopy, the understory, and the forest floor.

Materials: about two dozen seeds (pea, bean, or tomato), a large pot with drainage, soil, scissors

Procedure:

1. Plant three or four seeds in the corners of the pot, allowing about 15 cm between them. Water the seeds and place the pot where it will not receive direct sunlight for about ten days. After ten days, move the pot to a place where it will receive direct sunlight. Water the plants and have students record the progress of plant growth.


BLM

Old-growth forests contain trees that are more than 200 years old. The Northern spotted owl, a threatened species, depends on these forests for its habitat.

2. When the plants are about 15 cm tall and leafy (about three weeks) plant one to two dozen additional seeds in between the seedlings, being careful not to disturb the existing plants. Students should observe and record the progress of these new plants (they will be stunted and will not grow well).

3. After about three more weeks, remove one of the first plants and all but two or three of the stunted seedlings near it. (Remove them by cutting them off at the ground level, so the root systems of other plants will not be disturbed.) Students can record the growth of the plants in the thinned area and contrast these measurements with the other stunted seedlings, which should begin to thrive.

4. In a class discussion, draw the parallel of the potted plants with the rain forest plants and how shade affects growth there.

Teacher Resources

Web Sites

- The National Riparian Service Team homepage, including a "You Be the Manager" game http://www.blm.gov/riparian/manage.htm
- Temperate Forest Foundation http://www.forestinfo.org
- Domtar, Inc. http://www.domtar.com/arbre/english/index.htm
- World Forestry Center http://www.worldforest.org
- Smokey Bear http://www.smokeybear.com
- National Park Service, North Cascades National Park http://www.nps.gov/noca;
- Olympia National Park http://www.nps.gov/olym
- The Canopy Project http://canopyproject.org
- Oregon Coastal Environments Awareness Network http://www.ocean-oregon.org
- The Temperate Rain Forest Research Project Http://www.enviroweb.org/trrp/Educational/Edu.html
- Olympia School District Rain Forest Workshop http://kids.osd.wednet.edu/Marshall/rainforest_home_page.html

Other Resources

Project Learning Tree. An interdisciplinary environmental education program for PreK through 12th grade. Provides lesson plans, teacher workshops, and classroom materials. Information is available at http://www.plt.org.

About the Authors and Artist

Frances Philipek is an archaeologist in the BLM Salem (Oregon) Field Office; Shelley Smith is a resource manager in the BLM Utah State Office; Richard Brook is a BLM archaeologist in Washington, D.C.; and Shelly Fischman is a BLM environmental education specialist in Washington, D.C.

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